Enhancing high-nickel layered oxide cathodes for lithium-ion batteries

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Credit: Li, Erickson & Manthiram.

Lithium-based batteries are used to power most existing electric vehicles, yet the amount of time they can keep a vehicle going before they need to be recharged is still somewhat limited. In the future, high-nickel layered oxide cathode materials could help to increase the driving range of electric vehicles, enabling the development of cheaper and better performing lithium-ion batteries.

At the moment, most commercially available lithium-ion batteries use a significant amount of cobalt in one of their electrodes. Yet cobalt is expensive and not particularly abundant in nature, which significantly increases the fabrication costs of lithium-based batteries.

Scientists worldwide have recently been trying to identify new design strategies that could facilitate the widespread use of these batteries, as this could in turn reduce the prices of electric vehicles and increase the likelihood of their large-scale adoption. This may ultimately be achieved by identifying more abundant materials that could be used in lithium-based batteries, coming up with novel compositions, devising new production processes and introducing alternative structural designs.

In a paper published in *Nature Energy*, researchers at the University of Texas at Austin have outlined several design considerations for high-nickel layered oxide cathodes that could be implemented in lithium-based batteries over the next decade or so. Their study summarizes some of the challenges that are typically encountered when trying to maximize the energy output of high-nickel layered oxide cathodes, while also comparing some emerging designs for the creation of lithium-based batteries with a zero-cobalt chemistry.

"As we move forward with electrification of the transportation sector, the availability and affordability of cobalt could become an impediment for the widespread commercialization of lithium-ion batteries," Arumugam Manthiram, one of the researchers who carried out the study, told TechXplore. "The key objective behind our study was thus to reduce or eliminate cobalt and increase nickel in a lithium-ion battery's electrode."

The key advantage of using nickel instead of cobalt in electrodes is that it is less expensive and easier to find. Moreover, electrodes with high nickel content achieve a higher charge-storage capacity, energy density, and longer operation times between charges than cathodes with high amounts of cobalt.

Unfortunately, however, layered oxide cathodes containing high amounts of nickel can be very difficult to synthesize while still maintaining a good performance. In their study, Manthiram and his colleagues proposed a series of strategies that could optimize these current synthesis processes.

"Our most meaningful achievements are that we were able to synthesize electrode materials with high nickel content and lower cobalt content with good performance in lithium-ion batteries,"

Manthiram said. "However, the electrode materials with high nickel content are susceptible to be degraded when exposed to air. At present, we are focusing on stabilizing them to realize better stability in air."

The study carried out by Manthiram and his colleagues outlines a number of valuable design considerations that could soon enable the development of cheaper and better-performing lithium-based batteries using high-nickel layered oxide cathodes. The researchers also conducted a general evaluation of stabilization techniques that could potentially facilitate the widespread use of lithium-ion batteries, helping countries worldwide to meet their vehicle electrification targets.

"We are now focusing on further optimizing the compositions and stabilizations of the electrode materials we developed, as well as on scaling them up," Manthiram said.

More information: Wangda Li et al. High-nickel layered oxide cathodes for lithium-based automotive batteries, *Nature Energy* (2020). DOI: 10.1038/s41560-019-0513-0